BUG vs. BUG

JOHN ISAAC

STATE HORTICULTURAL COMMISSION

ELLWOOD COOPER, Commissioner

BUG VS. BUG

Nature's Method of Controlling Injurious Species

BY

JOHN ISAAC

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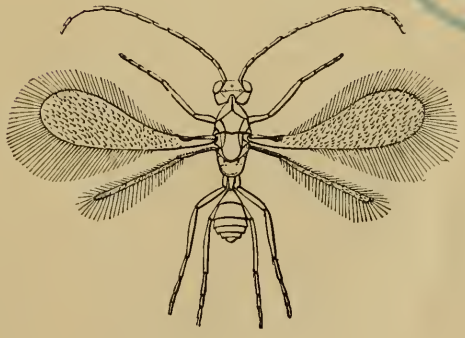

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BUG VS. BUG.

By JOHN ISAAC.

A somewhat small and unpretentious exhibit was that made at the St. Louis Exposition by the California State Commissioner of Horticulture, but it was one that attracted a great deal of attention, especially among scientific men and the more intelligent class of orchardists and farmers who visited that great exposition. This exhibit consisted of a very complete and well-arranged collection of the various insect friends to which California owes so much of her prosperity, and which are ever and continuously working in our interest. Many of these insects are exceedingly minute, so much so as to be practically out of the range of the naked eye. To overcome this difficulty they were displayed behind magnifying glasses of sufficient power to enable them to be seen, while descriptions of them and the work they are doing for our State were made in plain language. The result of this has been a great deal of inquiry from Eastern sources as to our beneficial insects and our California method of fighting bugs with bugs. To answer these inquiries, as well as to give our own people a wider knowledge of what our insect friends are doing for us, the following pages have been prepared.

Below is a list of the different insects exhibited at the St. Louis Exposition by this Commission:

PREDACEOUS COCCINELLIDÆ.

Beneficial Insects.	*Host Insects.*
Vedalia cardinalis	Cottony Cushion Scale (Icerya purchasi).
Novius koebelei	Cottony Cushion Scale (Icerya purchasi).
Novius bellus	Cottony Cushion Scale (Icerya purchasi).
Vedalia sp. (black)	Cottony Cushion Scale (Icerya purchasi).
Rhizobius ventralis	Black Scale (Saisseta oleæ).
Rhizobius ventralis, larvæ	Black Scale (Saisseta oleæ).
Orcus australasia	Black Scale (Saisseta oleæ).
Orcus chalybeus	Yellow Scale (Chrysomphalus [Aspidiotus] citrinus).
Rhizobius toowoombæ	San José Scale (Aspidiotus perniciosus).
Scymnus vagans	Red Spider (Tetranychus telarius).
Rhizobius debilis	Various scale insects.
Cryptolæmus montrouzieri	Mealy Bugs (Pseudococcus [Dactylopius] sp.).
Hyperaspis lateralis	Cypress Mealy Bugs (Pseudococcus ryani).
Exochomus pilatii	Various scale insects.
Chilocorus bivulnerus	San José Scale (Aspidiotus perniciosus), and others.
Coccinella sanguinea	Various scales and aphids.
Coccinella californica	Various aphids.
Coccinella abdominalis	Various aphids.
Coccinella oculata	Various aphids.
Hippodamia ambigua	Various aphids.
Hippodamia convergens	Various aphids.

PARASITIC HYMENOPTERA, DIPTERA, ETC.

Beneficial Insects.	*Host Insects.*
Scutellista cyanea	Black Scale (Saisseta oleæ).
Dilophogaster californica	Black Scale (Saisseta oleæ).
Hymencyrtus crawii	Black Scale (Saisseta oleæ).
Aphelinus mytilaspidis	Black Scale (Saisseta oleæ).
Aphelinus fuscipennis	San José Scale (Aspidiotus perniciosus).
Aspidiotophagus citrinus	Yellow Scale (Chrysomphalus [Aspidiotus] citrinus) and San José Scale (Aspidiotus perniciosus).
Pteromalus puparum	Internal parasite of the Cabbage Butterfly (Pieris rapæ).
Comys fusca	Brown Apricot Scale (Eulecanium armeniacum).
Encyrtus flavus	Soft Brown Scale (Lecanium [Coccus] hesperidum).
Coccophagus lecani	Soft Brown Scale (Lecanium [Coccus] hesperidum).
Coccophoctonus sp.	Yellow and Red scales.
Eupelmus mirabilis	Internal parasite of the Katydid (Microcentrum retinervis).
Braconid sp.	Parasite of Cutworm.
Anastatus sp.	Egg parasite of Tent Caterpillar.
Tachnia fly	Internal parasite of Cabbage Butterfly (Pieris rapæ).
	Internal parasite of Lecanium robinarum.
Aphelinus sp.	Internal parasite of Aphis.

Somewhere about the year 1868, a California nurseryman in San Mateo County, not far from San Francisco, imported some lemon trees from Australia. There was nothing unusual about this, nor was there apparently anything unusual on the trees themselves; nevertheless that importation cost the State of California millions of dollars and came near destroying one of the most important of its fruit industries, for on those trees, unseen and unnoticed by any one, were some of the young of the now well-known cottony cushion scale (*Icerya purchasi*). These soon reached their mature stage, and still no notice was taken of them; they were regarded merely as a curious object when noticed, and it was never dreamed that they were the commencement of one of the most terrible pests that California fruit-growers have ever known. The insects increased in numbers, but not being in a fruit section, and their depredations being confined largely to ornamental stuff, they were disregarded. Soon afterwards a Los Angeles nurseryman and florist secured some of the imported stock, with the imported pest, and so it was introduced into Southern California. Here conditions were better suited to it than even in the section where it had first obtained a footing in the State, and it spread much more rapidly. Soon it got into the orange orchards. Here conditions seemed perfect, and in a very short time it had spread to an alarming extent. Orchards in which it had become firmly established were covered with it until they looked as though they had been exposed to a severe snowstorm. It was soon found in remote sections, and in a short time appeared to have taken possession of the whole country. Nor did it confine itself to the orange trees; many varieties of fruit and a great quantity of ornamental plants fell beneath its attacks. It even found its way to forest trees, and for some time it looked as though it would reduce the whole country

to a desert. Orange-growers were in despair. From eight thousand carloads, shipments dropped to six hundred in one year. Every possible remedy was tried, but none was found effective, and even the most costly served only to temporarily check the spread of the pest. Orange-growers were digging out and burning their trees to get rid of the pest, but even this did not avail, for had all the orhards been destroyed there was sufficient wild stuff to keep it spreading.

In 1888 the National Government made an appropriation for the purpose of advancing the American interests at the Melbourne Exposition, and the appointment of the late Hon. Frank McCoppin as chairman of the commission to forward said interests was the nucleus of California's first effort in the search for natural enemies of orchard pests. McCoppin's friends in the orange district where this pest had caused such terrible losses urged that he should do something to save the orange industry. Correspondence was opened with the Hon. Thomas F. Bayard, Secretary of State, and through him, with the Department of Agriculture and the Entomological Division of that Department. This resulted in the sending of Albert Koebele, who discovered the *Vedalia cardinalis*, with the commission. While there were others in the State who were convinced of the parasitic theory and enthusiastic in their efforts to bring about the investigation, there was no available money until the above opportunity presented itself.

This discovery of a small ladybird known as the *Vedalia cardinalis* started California on her present course of fighting bugs with bugs, and no doubt this will continue until every insect pest that disturbs plant life and its fruits will be overcome by natural insect enemies, even if it should require traversing the very ends of the earth.

It is to be hoped that other states, and the National Government, will take up this work and thereby save hundreds of millions of dollars' loss that is now borne by the cultivators of the soil.

This ladybird was collected and forwarded to California and distributed all over the State wherever the scale had made its appearance.

Nearly, if not quite, all of the injurious pests of any section are introduced species, and in every case they have been introduced without their checks, for in its native habitat every pest, in fact every form of life, has some other form of life which preys upon it and prevents it from becoming redundant. Now, when any such form is removed to a new section, where it has no natural enemies, there is nothing to stop its unlimited spread, and as insects propagate more rapidly than any other form of animal life, without some check they would soon overrun everything within reach. These checks are usually other insects, and they are divided into two general classes—the predaceous class, or those which devour their prey from the outside, the most important among which is the great ladybird family, and the parasitic class, or those which

work in or on the body of their host. These latter are often microscopic, or very nearly microscopic, in size, but are among the most effective of our insect friends.

Usually each predaceous or parasitic insect attacks but one kind of insect; each has its own particular form of food and will touch no other. The *Vedalia,* for instance, lives wholly upon the cottony cushion scale, and if it can not get this, it will starve before it will touch any other form of food; so that, in searching for the enemies of our destructive insects, it is necessary to find just the right one.

It is a fact well known to all entomologists, that in their native homes, while insects are sometimes very troublesome, and in some sections exist in unusual numbers, they never become the serious pests that they do when they are removed to a new country where their checks do not exist. Usually in their native homes they are rather rare than otherwise. So when it is known that any pest is especially severe in any section, as, for instance, the San José scale (*Aspidiotus perniciosus*) over a great part of the Eastern States, it is very certain that it has been introduced there, and in order to find its check, we must find its native home, where it is scarce, and then we must find what agency is keeping it down. Sometimes our native parasites will adapt themselves to the introduced species, as has been the case in California with the San José scale. This pest was as great a terror to our growers some twenty years ago as it now is over a great part of the Eastern States; but one of our native parasites, the *Aphelinus fuscipennis,* adapted its taste to it, and finding in the San José scale a suitable food supply, it increased with almost unprecedented rapidity until it overtook the scale, and to-day this scale is no longer a pest in the California orchards. It is true that it occasionally makes its appearance in remote sections, but never to any dangerous extent, and the little parasite soon overtakes it and reduces it below the danger line. So little regard is paid to the San José scale in California now, that we never recommend any action against it. Spraying is still carried on, but this is more for the purpose of keeping the trees clean and healthy than for the purpose of getting rid of the San José scale. Before this parasite did such effective work, California orchardists were having very much the same experience that their Eastern brethren are having now, and trees by thousands were dug out and destroyed in order to get rid of the scale. It is to be hoped that the days of this terrible pest in the Eastern orchards are numbered, for it has been discovered that the same parasite which has freed the California orchards is now at work there, and in a report made by Prof. W. G. Johnson, when entomologist of Maryland, he says:

> Since we assumed charge of the State work in Maryland, we have collected the San José scale on various food plants and inclosed infested twigs, about four inches in length, in glass cylinder tubes, open at both ends; the ends were closed with cotton, and if any parasites existed upon the scale, they were easily detected and mounted for

study. Only upon rare occasions have we taken more than a half-dozen specimens from a single tube. This experience has been repeated year after year until the fall of 1899. * * * Last fall, however, I discovered a new locality for *Aphelinus fuscipennis*, near Easton, Talbot County, in an infested orchard along the Miles River. The orchard contained a miscellaneous variety of fruits, and all the trees were quite seriously infested with the San José scale. Instructions have been given the owner to cut them down as soon as possible and burn them. A quantity of small branches infested with scale were brought to the laboratory and inclosed in breeding tubes. Much to my surprise, these tubes were swarming with parasites a few days later. From one tube 1,114 specimens of *Aphelinus fuscipennis* were taken, while a second tube gave 432, a third 1,478, and a fourth more than 1,000, but owing to an accident the count in the case last mentioned was not exact.

The California method of fighting insect pests is to use the most efficient artificial means while we have to, and to this end we apply all sorts of known washes, dips, and fumigation, but, while so doing, we realize that these measures are very cumbersome, costly and inefficient, and that nature has provided a better way, and it is of this way that we avail ourselves. We endeavor to trace back the course traveled over by our destructive pests, to trail them to their native lair, and there we will find their check. This check, whether it be a parasitic or a predaceous insect, or both, as sometimes found, we secure, introduce, and breed, with the greatest care, in our insectary, where it becomes acclimated in its new home, and as it propagates it is sent into those sections where the pest upon which it is to prey is most prevalent. This method has been found so effective that we have now very few really troublesome orchard pests, the worst at the present time being the codling-moth, and for this we hope to find a natural check, and are now working toward that end.

It must not be supposed from this that there are no insect pests in California. We have been importing these pests from all parts of the world for half a century past and have had representatives from all parts of the world, and have them still, for when an insect once obtains a foothold, its eradication is practically impossible, but by introducing its natural enemy, we offset one against the other, and give ourselves no further uneasiness as to the outcome. The pests may do some damage, they may break out in sections in unusual numbers for a time, but invariably they are reduced below the line of serious damage shortly by the natural means, and it is done more effectively and permanently than can be done by any artificial method.

In an address before the fourteenth annual meeting of the Association of Economic Entomologists, Prof. C. L. Marlatt gave an account of a trip he had made to Japan and China in search of the native home of the San José scale, and in speaking of its discovery there he alluded to parasites which he found working upon it, and which are the same species which have done such good work on this pest in California. He said:

The apple industry of Japan is of recent origin, say within the last thirty years; most of the stock has been obtained from California, and as a rule was more or less

EXPLANATION OF PLATE I.

Fig. 1. *Novius koebelei*, Olliff; Koebele's ladybird. Male: enlarged.
1*a*. *Novius koebelei*. Male; natural size.
1*b*. *Novius koebelei*. Female: natural size.
1*c*. *Novius koebelei*. Larva; enlarged.
2. "Black Vedalia." Enlarged.
3. *Novius bellus*. Beautiful ladybird; enlarged.
4. *Novius* (*Vedalia*) *cardinalis*, Mulsant; Australian ladybird;
4*a*. *Novius* (*Vedalia*) *cardinalis*. Natural size.
4*b*. *Novius* (*Vedalia*) *cardinalis*. Larva; enlarged.
5. *Lestophonus icerya*. Dipterous parasite of the cottony cushion scale; enlarged.
5*a*. *Lestophonus icerya*. Natural size.
6. *Ophilosia crawfordi*. Hymenopterous parasite of the cottony cushion scale; enlarged.
6*a*. *Ophilosia crawfordi*. Natural size.
7. Twig infested with cottony cushion scale; natural size.
7*a*. *Icerya purchasi crawii*, Cockerell.
7*b*. *Icerya purchasi maskelli*.

BUG VS BUG.

THE BENEFICIAL INSECTS
THAT SAVED THE
CITRUS FRUIT INDUSTRY OF CALIFORNIA

infested with San José scale when received. Throughout this region the San José scale was found scatteringly in all orchards and in all gardens. In Aomori and vicinity it is doing no very great damage in any of the orchards, but in some of the small gardens and especially in one or two neglected ones in the city of Aomori, it was as abundant on particular trees as it often is in America. At the first investigation no evidence of parasitism was seen, but from later collections two of the parasites which attack the scale insect in America were raised in great numbers from infested branches collected at Aomori. These as determined by Dr. Howard are *Aphelinus fuscipennis*, How., and *Aspidiotophagus citrinus*, Craw, the latter being the more numerous.

This latter parasite is the true internal parasite of the Japanese yellow orange scale. The San José scale is not a native of Japan, so it is evident that this little parasite adapts itself to the introduced variety, which is a near relative of the yellow scale upon which it is generally found.

So effective has this work of introducing beneficial insects and encouraging native parasites been, that we have practically reduced all the worst of our scale pests and very many other destructive insects below the danger line. Among the many beneficial insects which are now at work in our State, and the pests which they are at work upon, and most of which they keep in control, we name the following:

COCCINELLIDÆ.

Vedalia cardinalis, Mulsant. (Plate I, Figs. 4, 4*a*, 4*b*.) This is commonly known as the "Australian ladybird," from the fact that it was imported from Australia in order to work upon the cottony cushion scale (*Icerya purchasi*, Maskell). As stated above, this pest had obtained such a foothold in our orange orchards that the citrus industry of California was threatened. The fact that the cottony cushion scale came from Australia, where it was not a pest, was sufficient proof that there was some very efficient check at work upon it there, and investigation by Albert Koebele discovered this little beetle. The orange-growers of Los Angeles County, especially, had a very expensive experience with this scale. As it had spread into the wild bushes and trees, extermination by artificial means was out of the question. Now the scale is no longer a pest. When it appears in an orchard the owner is supplied with a colony of *Vedalia*. During the summer the transformations of this ladybird are very rapid. From the egg, through the larva and chrysalis, to the perfect beetle, takes only twenty-one days. Of course, the larvæ are the most active feeders. When short of feed, the larvæ will attack each other, but no matter how hungry they are they will not eat any other species than the cottony cushion scale. This ladybird breeds throughout the year.

Novius koebelei, Olliff (Koebele's ladybird). (Plate I, Figs. 1, 1*a*, 1*b*, 1*c*.) This is another effective enemy of the cottony cushion scale

and does as good work as the *Vedalia*. The latter, however, was first introduced, and its reputation became so great that all others were overshadowed by it. The *Novius koebelei*, however, has proved itself equally as prolific and quite as voracious a devourer of the cottony cushion scale as its companion. This ladybird is also an introduced species, having been sent from Australia for the State Board of Horticulture by Mr. Koebele on his second trip to that country.

The illustrations give a good idea of this beautiful and active little ladybird. It feeds upon the cottony cushion scale (*Icerya purchasi*), searching out the solitary scales even better than the *Vedalia*. It passes through its different stages in about the same time as the latter.

FIG. 1. Novius koebelei, male, enlarged.

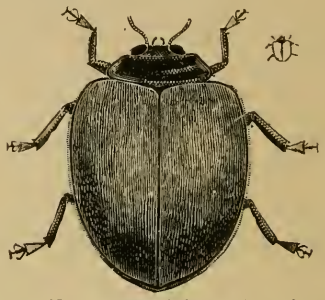


FIG. 2. Novius koebelei, female, enlarged.

Novius bellus (Beautiful ladybird). (Plate I, Fig. 3.) This is also an Australian species, having been introduced into California from that country by Mr. George Compere. It is one of the several coccinellid enemies of the cottony cushion scale, and has done very excellent work upon that pest. It has been generally distributed over the State.

Vedalia sp. (Plate I, Fig. 2.) This is an unnamed species of *Vedalia*, from its color commonly known as the "Black Vedalia." It is also an Australian species, introduced by the State Board of Horticulture through Mr. George Compere, and is another of the coccinellids which prey upon the cottony cushion scale.

Rhizobius ventralis (Black ladybird). (Plate IV, Figs. 3, 3*a*, 3*b*.) This is also an Australian ladybird, introduced by the State Board of Horticulture through Mr. Koebele, and is one of the natural enemies of the black scale (*Saisseta* [*Lecanium*] *oleae*). This ladybird was introduced for work on the black scale, and was generally distributed by the State Board of Horticulture wherever that pest was found. It was one of the most promising of the many importations of beneficial insects and took hold of its work with a vigor that gave promise of soon extirpating one of the worst of the California scale insects. Wherever it was introduced in the coast counties of the State, it increased with wonderful

rapidity and the scale as rapidly disappeared, and in those sections it still continues to do good work, but efforts to establish it in the interior counties have not met with as good success, the heat probably being too intense for the young larvæ. This insect, however, is well established all over the State, and in many sections is as abundant as any of our native species. Wherever it is abundant, it is a chief factor in keeping in check the destructive black scale.

Orcus australasia, Boisd. (Six-spotted blue ladybird). (Fig. 3.) This is one of the most beautiful of the introduced species. Like most

ORCUS AUSTRALASIÆ. Boisd (magnified); 1a. Ditto (natural size); 2 Pupa enveloped in larval skin; 2a Ditto (natural size); 3 Larva; 3a Ditto (natural size).

FIG. 3. Orcus australasia.

of the latter, it is a native of Australia, and was imported from that country by the State Board of Horticulture through Mr. Koebele. It is an enemy of the black scale (*Saissetia* [*Lecanium*] *oleae*), and is now well established in many parts of California, especially in the coast counties. The female is nearly one fourth of an inch in length, deep blue in color, with six orange red spots on the wing-covers. The male is similarly marked, but is a smaller insect. This species is a more general feeder than *O. chalybeus*. In Santa Barbara County it is bred on black scale, and in Alameda on the pernicious scale. It loves the sunshine, and is found more numerous toward the top and the outside branches of the trees in which it is established. The larva and pupa resemble the same stages of Pilate's ladybird.

Orcus chalybeus, Boisd. (Steel-blue ladybird). (Fig. 4.) So named from its brilliant steel-blue color, which makes it a conspicuous object wherever it is found. This ladybird preys largely upon the yellow scale (*Chrysomphalus* [*Aspidiotus*] *citrinus*, Coquillett), and also upon the red scale (*Chrysomphalus* [*Aspidiotus*] *aurantii*, Maskell), which it consumes in great quantities. This was introduced into California

FIG. 4. Orcus chalybeus, enlarged.

EXPLANATION OF PLATE II.

Fig. 1. *Encyrtus flavus,* Howard. Enlarged.
1*a*. *Encyrtus flavus.* Natural size.
2. *Coccophagus lecani,* Howard. Enlarged.
2*a*. *Coccophagus lecani.* Natural size.
3. *Comys fusca,* Howard. Enlarged.
3*a*. *Comys fusca.* Natural size.
4. Soft brown scale (*Coccus* [*Lecanium*] *hesperidum,* Linn.). On orange leaf.
5. Brown apricot scale (*Eulecanium* [*Lecanium*] *armeniacum,* Craw). On prune twig.
6. Brown apricot scale, showing exit holes of *Comys fusca.*

1a

1

2a

2

6

4

5

3a

3

BUG VS BUG.

THE INTERNAL PARASITES THAT HOLD IN CHECK
THE "SOFT BROWN SCALE" AND THE
"BROWN APRICOT SCALE" IN CALIFORNIA.

by the State Board of Horticulture some years ago and is now found established in many parts of the State.

Rhizobius (toowoombæ) lopantha. (Plate III, Fig. 6.) This little ladybird was formerly described under the name of *Scymnus marginicollis,* but is identical with *Rhizobius lopantha.* Mr. Koebele sent this beetle about the same time that he introduced the *Vedalia,* but it was found in the State previous to that. However, it has only been within the past few years that its value has been observed. It breeds from early spring until late in the fall. As compared with the beetles the larvæ are very large, they are light colored, with a lighter oblong square on center of the back, and remain a long time in the larval stage, feeding voraciously. When about to change to the chrysalis, they hide away under cobwebs, dry leaves, and other débris. The beetle is metallic black, with a brown thorax. They feed on *Aspidiotus perniciosus, Chrysomphalus (Aspidiotus) aurantii, Chrysomphalus (Aspidiotus) citrinus. Aspidiotus hederae (nerii),* and occasionally on aphis. In San Diego County it is proving effective on purple scale (*Lepidosaphes beckii*). In alluding to the excellent work of this little beetle on the purple scale in the above named county, Mr. Allen, of Bonita, writes:

With us the largest hatch of purple scale has usually been in May. So far this year I have not seen a single instance of purple scale hatching, nor can I find any live scale in an orchard adjoining us, every tree of which a year ago was literally alive with them. Since last July this orchard has been to my knowledge thoroughly stocked with the *Scymnus,* though when they first entered it I can not say. As they undoubtedly came in large numbers their work has been rapid.

I sprayed only a small part of the ranch last summer, and there can be no question but that, except for the work of this parasite, our place would be teeming with the purple scale, whereas I have yet to see the first live one, and our fruit, from trees that used to be infested, is now coming off the tree clean. I believe this ladybird is also eating the yellow scale, because there is so much less of it on the fruit, but of this I am not yet sure.

By September the efficiency of the purple scale parasite should be thoroughly established, for if any live eggs are left they must hatch before that time; yet even now it seems to me that the work of the *Scymnus* is second only to that of the *Vedalia,* and, considering the difference of the scales and the fact that the purple is so heavily armored, its work seems even more remarkable.

Scymnus vagans. This is one of the smallest of the ladybird family, but not one of the least important. It is an enemy of the red spider pest which is very general all over the world, and especially detrimental to almonds, prunes, and citrus trees. The long, dry seasons of California are favorable to the spread of this pest, which flourishes under arid conditions, and which has been especially troublesome here.

This little ladybird was introduced from Australia by Mr. George Compere for the State Board of Horticulture. It was found to be very effective in checking the spread of the pest, and has been generally established in California.

Rhizobius debelis. This is another one of the introduced species of ladybirds which we owe to Australia. It is a scale-feeder and has been very generally distributed in the State.

Cryptolæmus montrouzeri. (Fig. 5.) This is another of the Australian coccinellidæ. It is the natural enemy of the mealy bug (*Pseudococcus* [*Dactylopius*]). It has been introduced into the Hawaiian Islands, where this pest was so bad in the coffee plantations as to almost threaten the total destruction of the crop, and it has done such good work that the pest has been practically cleaned out. Successful efforts have also been made to establish it in the coffee plantations of Central America, where the mealy bug has also appeared in destructive numbers.

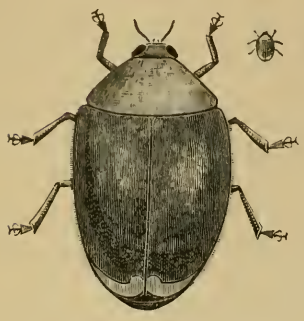


FIG. 5. Cryptolæmus montrouzeri, enlarged.

Hyperaspis lateralis, Mulsant. This is one of our native ladybirds and is very generally distributed over the State. It is a small, black ladybird, with two reddish-yellow spots on the elytra, near the apex, two spots on the disc, and two blotches of the same color on the forward lateral margins. Forehead and edge of thorax yellow. Feeds on pernicious scale in the adult form. Cypress trees (*Cupressus macrocarpa*) in the suburbs of San Francisco that were seriously infested with the cypress mealy bug (*Pseudococcus* [*Dactylopius*] *ryani*) were cleared of the pest by this ladybird. The larvæ of this species are covered with a cottony secretion and resemble mealy bugs.

Exochomus pilati, Mulsant. (Fig. 6.) This is another of our very common native ladybirds. It resembles in general appearance the twice-stabbed ladybird (*Chilocorus* [*bivulnerus*] *fraternus*), but is much larger. It also differs from the latter in having the under side of the extremity of the abdomen black, instead of red. The larvæ resemble the twice-stabbed, but are larger and lighter-colored. Both the larva and beetle feed upon young black scale, but they do not increase very rapidly.

FIG. 6. Exochomus pilati.

Chilocorus (bivulnerus) fraternus (Twice-stabbed ladybird). (Plate III, Figs. 3, 3*a*.) This is one of our most important native ladybirds. The larvæ are most voracious, and destroy great numbers of young black, pernicious, and other scales. The young are long and covered

with dark spines, crossed with a yellowish band near the middle. When about to change into the pupa or chrysalis, the larva selects the under side of the large branches, where it attaches itself with a gummy substance to the bark, head downward. In a few days the spiny, larval skin splits longitudinally, exposing the inclosed chrysalis. When the beetle issues from the chrysalis it has a black head, with white wing-covers; in a short time this changes to a shiny black, with a red spot on each elytra. In this stage it also preys upon scale insects.

Coccinella sanguinea, Linn. (Blood-red ladybird). This is a medium-sized native species, found very generally distributed over California. It feeds upon aphids and young scale insects, but is not so common as some of the other species, and is not, therefore, so beneficial. The beetle is of a solid color, varying in intensity from a dull red to a bright scarlet.

Coccinella californica, Mann. This species is a very common one in this State, and the beetles are sometimes found in enormous numbers. They are very social in their habits, and can sometimes be found in such numbers as to be gathered by quarts. They are larger than the *sanguinea*. The elytra are orange-red, without spots or markings; thorax is black, with a light spot on each side. They feed principally on aphids. Like other species of ladybirds, the larvæ do the most good.

Coccinella abdominalis, Say. This is known as the "ashy gray ladybird," from its prevailing color. This ladybird is hemispherical in form, ashy gray in color; with seven small black spots on the thorax and eight on each wing-cover. It is said to be one form of *Coccinella oculata*, Say. It is an aphis-feeder, and where it exists in quantity does good work.

Coccinella oculata, Say (Eyed ladybird). This, while it is supposed to be one form of the preceding, does not resemble it in any manner, in its markings or general appearance. The adult insect is deep black in color, with two distinct orange-red spots on the wing-covers, and might easily be mistaken for *Chilocorus fraternus*. There is a distinct difference in these two insects in the markings of the thorax, the *oculata* being light yellow on the under side and around the margin of the thorax. Like its other form, *abdominalis*, it is an aphis-feeder, and a very effective one where it is found; but in this form it is not a common insect in this State.

Hippodamia convergens, Guer. This is another of the common ladybirds of California, and is found throughout the State during the summer months very plentifully, among corn and other vegetables. The larvæ feed upon aphids and other insects, while the mature insects

EXPLANATION OF PLATE III.

Fig. 1. *Aspidiotophagus citrinus,* Craw. Enlarged.
1*a*. *Aspidiotophagus citrinus.* Natural size.
2. *Aphelinus fuscipennis,* Howard. Enlarged.
2*a*. *Aphelinus fuscipennis.* Natural size.
3. *Chilocorus bivulnerus;* "twice-stabbed ladybird." Natural size.
3*a*. *Chilocorus bivulnerus.* Larva. Natural size.
4. San José scale (*Aspiodiotus perniciosus,* Comstock). Natural size. On pear twig.
5. Yellow scale (*Aspidiotus citrinus*, Coquillett). Natural size. On orange leaf.
6. *Rhizobius* (*toowoombae*) *lopantha.* Natural size.

BUG VS BUG.

THE FOUR SPECIES OF INSECTS THAT SUBDUED THE
"SAN JOSE SCALE" AND "YELLOW SCALE"
IN CALIFORNIA.

also feed upon aphids, young scale, etc. The beetles vary somewhat in color; some are of a deep red, while others are of a dull brown, the markings, however, being uniform. Sometimes after ripe fruit has been punctured by birds or other agencies, the beetles of this species will be found upon it, sipping the moisture, and on this account they have been thought sometimes to be injurious. They are, however, among the most important of our insect friends.

Hippodamia ambigua, Le Conte. (Figs. 7, 8, 9.) This is a very abundant native species. The adult beetle resembles the blood-red ladybird somewhat, but is narrower in proportion to its length, and flatter. It is distributed over the whole State, and is often found in great numbers. It is an aphis enemy, and does excellent work on the plum, apple, and woolly aphis. During the later fall months these insects may often be found in sheltered places in great masses, in which condition they hibernate during the colder months.

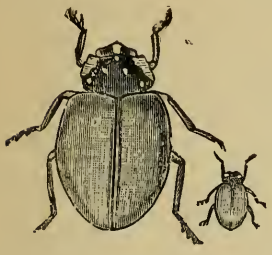


FIG. 7. Hippodamia ambigua, enlarged.

FIG. 8. Hippodamia ambigua, pupa.

FIG. 9. Hippodamia ambigua, larva.

HYMENOPTERA.

Scutellista cyanea, Motsch. (Plate IV, Figs. 1, 1*a*, 1*b*, 1*c*.) This is comparatively a new introduction into our State, having been secured from South Africa, where it was found to be a very effective worker on the black scale (*Saisseta oleae*). In the short time it has been established among us, it has done most remarkable work, and, so far, promises to be as efficient a check for the black scale as the *Vedalia* has been on the cottony cushion scale. Of its introduction, Mr. Craw writes:

It was not until Prof. Charles P. Lounsbury, Government Entomologist of Cape Colony, called attention to the *Scutellista cyanea* as an efficient enemy of the black scale in that country, that its true value was recognized.

Through the efforts of the Hon. S. F. Leib, of San José, and Mr. Ed. M. Ehrhorn, of Mountain View, Senator Perkins appealed to the United States Department of Agriculture to use its good offices toward securing this valuable insect. Several colonies were forwarded to Mr. Ehrhorn, but, unfortunately, without any practical results from either sending. On October 1, 1901, Professor Lounsbury wrote me:

"By to-morrow's boat we start you two boxes containing cuttings of oleander bearing parasitized scale. It is not ideal material by any means, and this is not the season we most wish to send in, but the scale and its parasites are both so scarce that we must send what we find as soon as we find it. Most of the scale in your

vicinity will be old by the time this reaches you, but I am in hopes that you may be able to get material from the south of the State that will take a generation of the parasite. Owing to the probable presence of secondary parasites, it is, of course, inadvisable to send the original material to any orchardist down there."

From this sending, seventeen perfect insects developed, of which four were females. When placed in a breeding case, a small spider that was hidden in a rolled-up leaf seized and killed one of the females, leaving us but three from which to colonize the State.

On December 26, 1901, I examined a full-grown black scale from the tree in the breeding case, and found a small maggot of the *Scutellista cyanea*, about twice the size of a black scale egg. This convinced me that they were breeding, so no further examination was made. On February 7, 1902, the parasites began to issue from the scales. During the warm summer months we found that the *Scutellista* passed through all its metamorphoses in forty-seven days.

Colonies have been sent to all the counties of the State where black scale has been troublesome. From personal examination and from material sent in, it is evident that the parasites have obtained a good start, and the coming season will, we hope, see them thoroughly disseminated.

Description: In the female, the antennæ are reddish-brown, with the ring joints and hips dark and more spreading than in the male. The antennæ of the male are black from the ring joints to and including

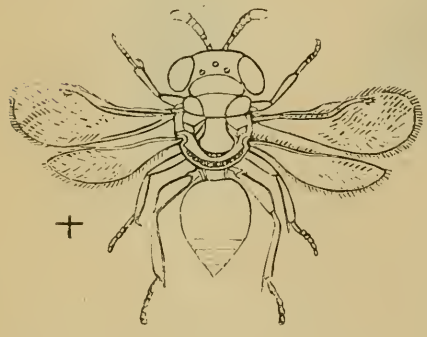


FIG. 10. Tomocera californica, male, greatly enlarged.

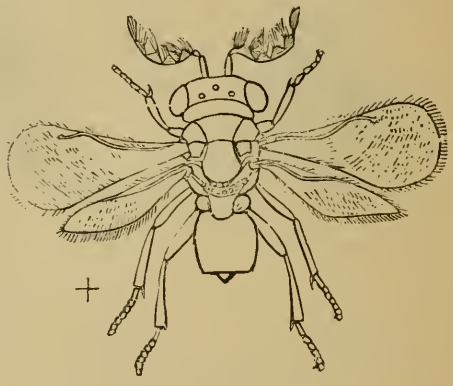


FIG. 11. Tomocera californica, female, greatly enlarged.

the clubs, with the scape reddish-brown; the legs in both sexes are black, tarsi reddish-brown, and claws black; the scutellum in both male and female is very large. As the flies are small and very active, it is difficult to detect them on the tree upon which they may be placed, and the best way to determine if they are established, is to remove and examine the inside of the full-grown scales about forty to forty-five days after liberating the parasites. The larva is maggot-shaped and white, this soon changing to the pupa, which is black just before changing to the perfect fly.

Tomocera (Dilophogaster) californica, Howard. (Figs. 10, 11). This is one of our native internal parasites. In has been one of the most effective checks of the black scale in the State, but was not able to keep

this pest wholly under control. In a report on scale insects and their parasites, Professor Comstock says of this insect:

This is one of the most interesting parasites, both structurally and economically, which we have discussed in this paper. It lives upon the destructive black scale, and so abundant is it in certain regions that upon more than one tree at least seventy-five per cent of the scales appeared to be parasitized. In no locality was the black scale found without this attendant destroyer.

The female parasite pierces the body of the female bark-louse and deposits probably but a single egg. At all events but a single parasitic larva has ever been found upon a single scale. The larva of the parasite feeds upon the eggs and the young of the *Lecanium*, and, also, later upon the mother herself. When full grown it is about 0.15 inch long, broad, spindle-shaped, somewhat more pointed at the anterior than at the posterior end of the body. Its color is clear white, the contents of the alimentary canal, however, often showing through and giving it a blackish tinge. This larva transforms to a whitish pupa, which soon turns black. The adult parasite makes its exit through a round hole which it cuts in the back of the scale.

Hymenocyrtus crawii, Ashmead. This is an Australian insect, and is one of the very effective internal parasites of the black scale in that country. It was introduced into California by Mr. George Compere, and has been reported as doing very good work in the districts where it has become established.

Aspidiotophagus citrinus, Craw. (Plate III, Figs. 1, 1*a*. See Fig. 12.) The internal parasite of the yellow scale (*Chrysomphalus* [*Aspidiotus*] *citrinus*) and the San José scale (*Aspidiotus perniciosus*). The former scale was at one time as great a source of trouble to the orange-growers of southern California as the red scale (*Chrysomphalus* [*Aspidiotus*] *aurantii*) is now. It fairly covered the citrus trees, reduced the quantity of fruit, and destroyed its quality. Every effort was made by artificial means to resist its attacks, but these were unavailing. Finally it was discovered that there was some natural check at work, and investigation discovered this little internal parasite. Instructions were at once given to the orange-growers to stop spraying for the yellow scale and to give this little friend a chance to increase. This advice was followed, and in a very short time the yellow scale disappeared from that section and it has not since been regarded as a pest, although no other means have been taken to check it. Mr. Craw has bred this parasite from yellow scale upon imported trees from Japan. Mr. Marlatt bred it in numbers from San José scale in Japan. It is also one of our best checks for the same scale in California.

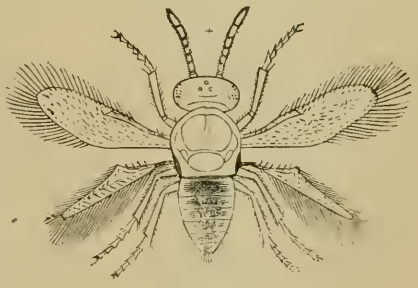


FIG. 12. Aspidiotophagus citrinus, greatly enlarged.

EXPLANATION OF PLATE IV.

Fig. 1. *Scutellista cyanea,* Motsch. Female: enlarged.
1*a*. *Scutellista cyanea.* Natural size.
1*b*. *Scutellista cyanea.* Larva; natural size.
2. *Scutellista cyanea.* Male; enlarged.
3. *Rhizobius ventralis,* Blackburn. Black ladybird; enlarged.
3*a*. *Rhizobius ventralis.* Natural size.
3*b*. *Rhizobius ventralis.* Larva; enlarged.
4. "Black Scale" (*Saissetia* [*Lecanium*] *oleae,* Bern). On orange twig.
5. "Black Smut"; fungus, existing on exudation of black scale.
6. "Black Scale," showing exit holes of *Scutellista cyanea.*

BUG VS BUG.

THE TRUE PARASITE AND ENEMY

OF THE

"BLACK SCALE

Aphelinus fuscipennis, Howard. (Plate III, Figs. 2, 2*a*.) It is well within the memory of the fruit-growers of California when the San José scale was the most terrible of our pests. It antedated the appearance of the cottony cushion scale and attacked nearly all of our deciduous fruit trees. For some time it seemed as though the fruit industry of our State was doomed, at least such varieties as were attacked by this pest, and orchardists were digging out and destroying their trees by thousands in order to stay its ravages. Various compounds were devised to fight it; among them the now celebrated wash of salt, sulphur, and lime was discovered as most effective. This wash is still the best known artificial remedy for San José and kindred scales on deciduous trees; but it is impossible with the greatest care to destroy any kind of pest by artificial means. There are always solitary trees which will be neglected, careless people who refuse to spray, wild shrubbery out of reach of the operators, and all of these become sources of infection. While active and efficient work was being done by artificial means against this pest, it was discovered to be disappearing in sections where no spraying was done, and investigation showed that one of our native parasites, the *Aphelinus fuscipennis*, had adapted its taste to it and was rapidly getting it under. To-day, wherever the San José scale is found we also find its parasite, and while the pest has not, and never will disappear, it is entirely controlled by its little enemy until we pay no further attention to it. Spraying is still carried on, however, as it has been found beneficial to our fruit trees in killing other pests, preventing fungous diseases, and keeping the trees healthy; but so far as the San José scale is concerned, there is no further need of artificial remedies.

This same parasite is generally distributed all over the United States and is undoubtedly doing good work, as shown in our quotation from Prof. W. G. Johnson of Maryland, but the long winters and comparatively short summers there may check its spread. In the mild winters and long summers of California it probably has more broods than there, and, increasing in greater quantity, it is enabled to do more effective work.

Pteromalus puparum. This is a very common enemy of the cabbage butterfly (*Pieris rapae*) in this State, and undoubtedly to its work is due the fact that this pest is not more common than it is. This parasite has a wide range and is found over the greater part of the United States. It is parasitic upon the pupa of the butterfly, upon which it lays a number of its eggs, which, hatching out in its unfortunate victim, puts an end to its career. Prof. F. M. Webster in "Insect Life" gives an interesting account of the operations of this insect, as follows:

On the morning of August 9th, we observed a larva of *Pieris protodice*, Boisd., in the act of transformation to the chrysalis. Near by, and very evidently watching this transformation, were a male and female of this parasite. The trio were observed several times during the early part of the day, the parasites always on guard, as it

were, although the females several times were observed to attempt oviposition, in every case, however, being deterred from so doing by the jerking of the larva, now in a semi-pupal state. During one of these visits the male was driven away, but soon returned. About 6 P. M., the last observation of the day, the transformation of the larva, while not complete, had so far advanced as to prevent the radical movements which had characterized its struggles during the forenoon, and the female was busily engaged in her work of oviposition, the male still present as a spectator (?). On the morning of the 10th, the chrysalis, now fully developed, was removed and placed in a glass jar, awaiting further developments. On the morning of the 27th, seventeen days after, the adult *Pteromalus* were observed issuing from the chrysalis in great numbers. After all had emerged, they were counted and found to number 68 males and 4 females. The same parasite had been reared from a similar chrysalis on August 13th, but the individuals were not counted.

Comys fusca, Howard. (Plate II, Figs. 3, 3*a*.) This is one of the most effective of the scale parasites in our State. Its efforts are principally directed to keeping down the brown apricot scale (*Eulecanium* [*Lecanium*] *armeniacum,* Craw), and wherever it has become thoroughly established it has accomplished this object in very good style. The brown apricot scale has been one of the most serious scale pests of the State, frequently covering the twigs of apricot, plum, and prune trees with an almost solid incrustation, destroying the vitality of the trees, ruining the fruit, and doing incalculable damage. By means of this little internal parasite, however, we are enabled to keep the pest well under control, and whenever there is an outbreak of the scale, colonies of the parasite are sent and soon become established. The parasites are small, and their capture and shipment require great care. The method in which this is done is by noting an orchard in which the insects are well established the preceding season. From this orchard large quantities of infested twigs are secured about the middle of May, or before the parasites begin to emerge from the scale. These are carefully trimmed of all leaves to prevent mildewing, and then placed in square, wooden receptacles or boxes, as shown in the illustration (Plate VIII). These boxes are bored with a number of half-inch holes in the upper half and all light elsewhere excluded. Into these holes small vials are fitted, with the mouths inward. The insects, as they emerge from the scales, seek the light and enter the vials placed to receive them, and when there are enough in any one to form a colony of sufficient size, usually from twenty-five insects up, the vial is removed, stopped with a little cotton wool to prevent their escape and yet admit air, another vial is set, and the process is repeated. The vials are then carefully packed in stiff paper tubes (see Plate IX) and mailed to all sections where there have been any reports of outbreaks of the scale. In this manner, beneficial insects are distributed by tens of thousands all over the State and nature is aided in her efforts to keep our insect enemies within proper limits.

Encyrtus flavus, Howard. (Plate II, Figs. 1, 1*a*.) This is one of several internal parasites of the soft brown scale (*Coccus* [*Lecanium*]

hesperidum). This scale was another of the very serious pests which the orange-growers of California had to contend with and from which they have been relieved by insect aids. When orange-growing was in its infancy, the soft brown scale obtained a foothold in the orchards, and without any check soon spread. In a short time the trees were covered with it and were suffering greatly from its depredations. In a comparatively short time, however, it began to disappear, and investigation showed that several internal parasites, among which the *Encyrtus flavus* was one of the most important, were actively at work upon it, and reducing it below the danger limit.

Coccophagus lecani. (Plate II, Figs. 2, 2*a*.) This is another of the internal parasites of the soft brown scale (*Coccus hesperidum*). It is found in several of the *Lecaniums*, but its best work in this State has been on the soft brown scale of the orange, which, in connection with *Encyrtus flavus*, it has kept below the danger limit.

Coccophoctonus sp. This is an internal parasite of both the yellow and red scales, and while it has not done as extensive work as some of the other parasites above described, it is none the less an important addition to our list of friendly insects.

Eupelmus mirabilis, Walsh. This is an egg parasite of the katydid (*Microcentrim retinervis*, Scudder). The female insect lays her eggs within those of the katydid. The young parasite is hatched and at once proceeds to eat the eggs of the host insect. The *Eupelmus mirabilis* has been an invaluable friend to the orchardists of California and especially to those engaged in orange-growing, where at one time the katydid was an annoying and destructive pest. It is now rather a rare insect in those sections where it was once so common, and it is difficult to find its eggs without observing that they have been perforated and destroyed by this parasite.

Besides the above-named insects which are common in California, and to which without doubt we owe our position as a fruit-producing State, there are a number of others of greater or less importance, among them a species of *Braconid*, parasitic on cutworms; *Anastatus*, an egg parasite of the tent caterpillar, and another parasite of the tent caterpillar eggs. There is also a Tachnid fly which destroys the cabbage butterfly by laying its eggs on the victim, the young larva hatched from which eats up the caterpillar and destroys it. There is also an internal parasite of the *Eulecanium* (*Lecanium*) *robinarum*, Douglas, and a species of *Aphelinus* working as an internal parasite of the aphis.

DIPTEROUS INSECTS.

In the great family of dipterous or two-winged flies, we find very many of our worst pests; among them the many fruit flies, which do so much damage by laying their eggs in the ripening fruit, and which hatching out into a mass of crawling maggots render it wholly unfit for use; but at the same time this order gives us very many of our best friends, and prominent among them are the following:

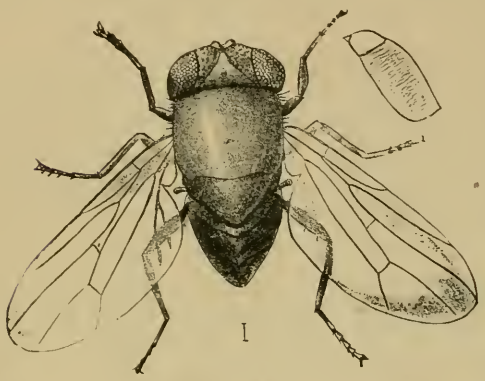
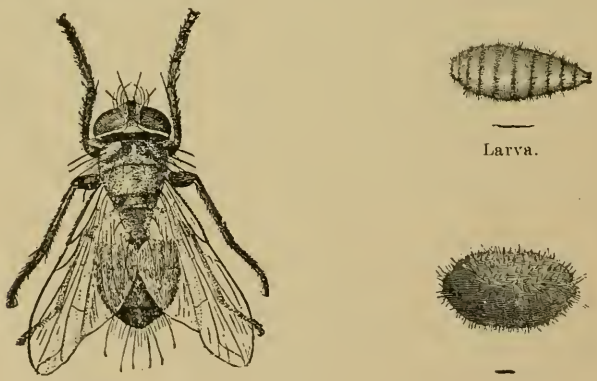


FIG. 13. Lestophonus icerya, enlarged.

Lestophonus icerya. (Plate I. Figs. 5, 5*a*; also Fig. 13.) This is an exceedingly small, two-winged fly, which was found at work on the cottony cushion scale at Sidney, N. S. W., by Albert Koebele. It is now thoroughly established all over California wherever the cottony cushion scale is found, and has proved itself a valuable auxiliary to the *Vedalia cardinalis* in keeping that pest in check.

Celatoria crawii, Coquillett. (Fig. 14.) This is another of our beneficial flies, being an internal parasite of the well-known twelve-spotted squash beetle, so common in fruit-growing districts, and is one



Female, enlarged. Larva. Pupa.

FIG. 14. Celatoria crawii, Coquillett.

of the rare instances that have been recorded of a beetle being destroyed by the larvæ of a fly. It is not only interesting to an entomologist, but is of great assistance to the horticulturist in reducing the numbers of such a serious pest. Mr. Craw discovered this parasite in the neighborhood

of Los Angeles, where he collected a large number of the beetles, and found that fully one third were parasitized. He found them in the larval state in the beetles as early as May and as late as the middle of October. The May brood pupate early in June and remain in this condition about two weeks, when they change to the winged form. They are numerous in July and August.

Masicera pachytyli, Sk. (Fig. 15.) This is one of the Tachnid flies, the whole of which family are parasitic on other insects. They are of medium size generally, and to a casual observer resemble our common house flies. The favorite food of the greater part of the members of the family are the caterpillars. The female lays her eggs on the soft bodies of the caterpillars and the young grubs devour their host, which never attains its mature state. It is to this family that the reduction of moths and butterflies below the danger limit is due. The one of which we give an illustration in Fig. 15 is parasitic on the locust, and unquestionably does much toward keeping this terrible pest in check in Australia, where it is native. This is one of the introduced species and has been established in our State. Mr. A. H. Bray gives his observations on this insect, as follows:

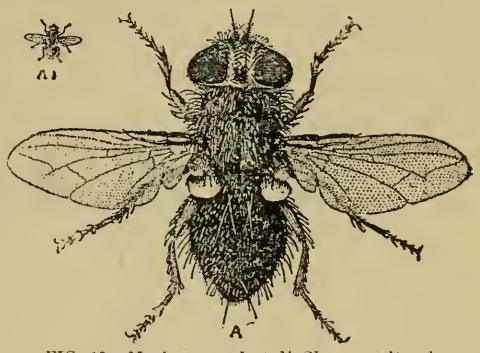


FIG. 15. Masicera pachytyli, Sk., parasite of the locust.

The grub, or larva, is found within the locust, where it appears to live upon the adipose tissues of the victim, avoiding the vital parts with unfailing instinct. The grub lives indifferently in the thoracic region or the abdomen of the locust, and frequently three or four may be found in a single grasshopper.

The grubs leave their victims when they are full grown, usually by means of an opening which they eat in the side of the locust at the point where the abdomen joins the metathorax; but they do not invariably make their exit from the body of the unwilling host at that particular place, as on one occasion I observed two grubs escaping from a grasshopper at the same time—one from between the first and second abdominal segments, and the other from between the head and prothorax. As soon as the grub makes its escape, the grasshopper, which has gradually grown more and more feeble as the inclosed parasite has gained in size, dies. In several instances I have observed that the grasshopper died before its enemy succeeded in making its escape; and in one case a larva was seen vainly struggling to free itself from between the metathorax and the abdomen of a dead grasshopper, where it was firmly held by the contracting remains of its victim. The grub, which subsequently died without extricating itself, succeeded in freeing more than half its body, but it was firmly held by the tail.

The **Syrphidæ,** or syrphus flies (Figs. 16, 17, and 18), are another large family of dipterous insects, many of which are beneficial to man.

They are usually very conspicuous from size, color, and markings, and very many of them resemble other insects and may be mistaken for bees, wasps, etc. They are often seen in sunny weather poising almost motionless on the wing, especially over flower-beds, occasionally darting on their prey. The larva of the syrphus flies is of great benefit in destroying all kinds of aphids. It is quite blind, but the egg from which it hatches is deposited by the parent fly in the midst of a colony of plant aphids, where it gropes about and obtains an abundance of food without much trouble. The larva is fleshy, thick and blunt behind, and pointed in front. Its mouth is furnished with a triple-pointed dart, with which it seizes and pierces its prey, and, elevating it as shown in the figure, deliberately sucks it dry.

FIG. 16.
Larva of Syrphus Fly.

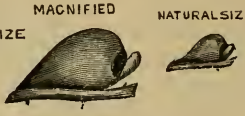


FIG. 17.
Pupa of Syrphus Fly.

FIG. 18.
Syrphus Fly.

This is but a partial list of the very many insect friends which are doing so much for California horticulture, and which it has been the policy of the State Board of Horticulture and the State Horticultural Commissioner to foster and encourage to the widest extent, and at the same time to add to their numbers all beneficial insects which can be secured from any part of the world. To this end correspondence is carried on with entomologists in different parts of the world, while agents of this department are dispatched to discover and introduce beneficial species wherever they can be found. It is the policy of this State to use artificial remedies so long as there are no better ones, but to secure, introduce, and distribute the better means, and these consist of beneficial insects, as soon as possible. In California, at least, this plan has been found a very effective and profitable one, for of all the many insect pests which have been found here, and they are as numerous as anywhere on earth, and have been imported from all parts of the earth, there are not now more than two or three really serious species, and all are controlled by their insect checks, either native or introduced; and so far as those for which we have not yet found an effective parasite are concerned, we are now searching for one, and in view of our past success in this line, will undoubtedly find it.

PLATE V. Office of the Horticultural Commission in San Francisco, showing insectary and breeding-jars in the background.

PLATE VI. Breeding-cases for beneficial insects, in San Francisco office.

PLATE VII. Insect breeding-jars, showing method of breeding and capturing beneficial insects for shipment.

PLATE VIII. Trap boxes, showing method of catching beneficial insects for transportation. Scale-infested twigs, containing the parasites, are placed in the boxes, and as the insects hatch they work to the light shown in the tubes and are captured without being handled.

PLATE IX. Beneficial insects ready for mailing. Showing a section of one tube removed to illustrate method of packing.